Advanced Conformal Side Looking Sonars For Small Underwater Vehicles

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LONG-TERM GOAL

The long-term goal of this task is to develop conformal Synthetic Aperture Sonar (SAS) for small vehicles that can classify/identify proud targets and classifiy buried targets. This vehicle and the acoustic sensor must operate effectively in the very harsh environment of the very shallow water (VSW). The goal is to make the sonar system and its platform small and low cost.

OBJECTIVES

The objective is to develop a sonar with enough reverberation rejection to detect, classify and approach identification quality images of proud targets in the VSW environment. In addition, the sonar will detect and classify partially buried targets in the VSW environment. To achieve this objective we will develop a self-contained, adaptively focussed SAS that will fit in a nine-inch inside diameter body and be less than three feet long.

APPROACH

The approach will be to design the SAS using computer design procedures based upon past SAS designs and to test the design with a computer simulated environment including vehicle motion. This will be followed by tests of a fabricated prototype in a controlled acoustic test pool, and then finally, the system will be taken to sea. The challenge is to put this design in a small vehicle with all the signal processing necessary to generate high resolution images of proud and buried targets in the VSW environment. The sonar will initially be a single-side design. Once the design is proven, the other side can be fabricated. Initially this design will have a separate projector in front of the receive array. This approach will reduce the development risk in fabrication and testing. It will have both a low frequency and a high frequency section that will operate simultaneously. This dual frequency operation will separate the buried objects from those that are proud.

The design will be modular in 8-channel electronic receiver sections. Each 8-channel section will be interfaced to a fiber optic cable. Each section will consist of two 6U cards, one for the analog processing and A/D conversion and a second with the digital signal processing and fiber interface. The fiber optic interface will be an industry standard such that any computer that has this standard interface and the I/O bandwidth can be connected to this sonar.

The Low Frequency Projector (LFP) will be installed in a separate transmitter housing that will be directly forward of the receiver section as shown in Figure 1. The high frequency projector, due to its small size will be mounted directly beneath the receiver array. The high frequency projector is a low risk component and is physically small, making this layout feasible. The low frequency projector is much larger and must be placed in a separate housing. This approach also allows the flexibility in the future to replace the LFP with new or modified LFPs with no modifications to the rest of the system.

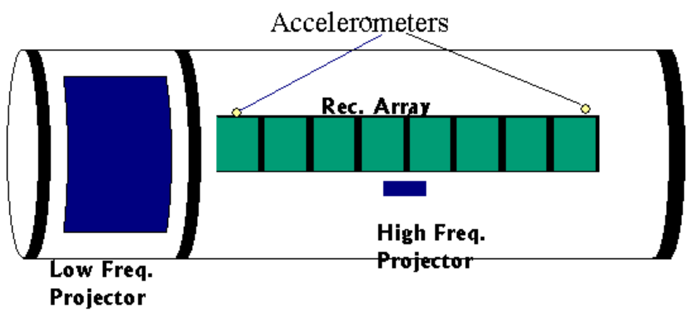

Figure 1. Array Diagram

The data will be recorded within the vehicle and returned for offline high resolution SAS processing.

The testing philosophy will be to produce a functioning SAS that has been completely tested, then to install and test it in a small AUV that has been well characterized. Some attention must be devoted to the small AUV and its dynamic characteristics in order to minimize the motion errors that will occur. Smaller vehicles inherently have higher frequency motion components. The initial testing of the SAS prior to the installation in the small AUV will isolate the sonar problems from the vehicle induced electrical problems.

When both the vehicle and sonar are fully tested, the sonar will be integrated into the vehicle, and testing will occur in four steps. The first will be bench tests with all systems operating to determine interference issues. The second will be an in water static testing to determine vehicle systems acoustic compatibility with the sonar. The third test will be in the large acoustic test facility. The vehicle will be allowed to run a preset path around the test pool. This will reduce testing risk by conducting the tests within a confined area where the vehicle can be easily recovered in case of mishap. The fourth testing phase will be in St. Andrews Bay and the Gulf of Mexico over a known target field. The present plan is to start initial testing in deep water (>60 ft) and progress into the VSW region.

In addition, once the system proves to be reliable, tests would be conducted in various sea states, with vehicle safety being considered, to characterize its VSW performance over various sea states and bottom types. This will also enhance the Navy's database in this region and will be very useful in characterizing CAD/CAC algorithms in this very difficult environment.

WORK COMPLETED

The basic array design is complete and is shown Figure 1. The hardware design is finalized and fabricated. Bench testing of the individual components has been completed and all components have passed. Pool tests and hardware testing will be completed by the end of November 2000. The beamformer for this sonar is complete.

RESULTS

Figures 2 and 3 show predicted images of a truncated cone for the high frequency and low frequency, respectively, in 20 foot of water with the vehicle at 10-foot altitude and a range of 30 meters. These results were generated using Imaging SWAT 3.51. The images were generated with a medium sand bottom and sea state 1.

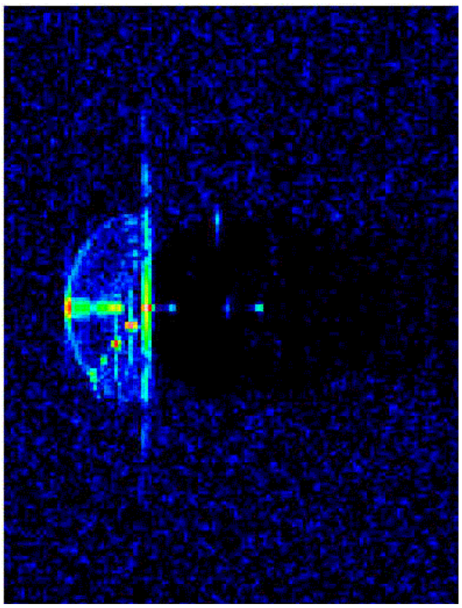

Figure 2. 120khz SAS Image of a Truncated Cone.

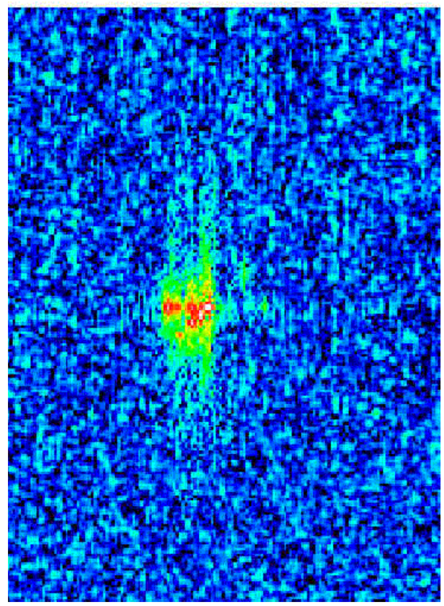

Figure 3. 20khz SAS Image of a Truncated Cone.

IMPACT/APPLICATIONS

The small SAS sonar will be useful for all small vehicles in that it will be a small, low power device that can produce extremely high resolution sonar images of very small objects. Objects that in the past could not be classified due to their small size will be easily classified with this sonar. This small sonar will also be useful from small craft as a towed SAS in place of less capable sidescan sonars. This will enable small craft to have access to a very high performance side scan sonar that can be towed at 5 knots with a maximum range of 45 meters.

TRANSITIONS

This sonar is planned to transition into a VSW autonomous underwater vehicle used by the U.S. Navy for VSW/SZ mine hunting operations through either a United Stated Special Operations Command or Very Shallow Water Mine Countermeasures Detachment program.

RELATED PROJECTS

The Coastal Systems Station has a High Frequency/Low Frequency Synthetic Aperture towed sonar that has been operational for several years and has participated in a number of U.S. Navy exercises such as Kernal Blitz, MIREM and Fleet Battlelab Experiment (FBE)-Hotel. It has also been used to search for debris during the Swissair 111 crash.

PUBLICATIONS

Christoff, J.T. and J.E. Fernandez, 1999. Synthetic Aperture for Small Unmanned Underwater Vehicles, *Proceedings of SPIE, Information Systems for Navy Divers and Autonomous Underwater Vehicles Operating in Very Shallow Water and Surf Zone Regions*, Vol. 3711, pp. 68-78, 7-8 April.

PATENTS

Matthews, Tony and Christoff, James, 1999. Patent Submission: <u>Adaptive Multistatic Synthetic Aperture Sonar</u>, Navy Case Number 79842.